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Exploring Nutritional Stress as a Possible Cause of the 2019 Unusual Mortality Event in Gray Whales

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Aims

Rapid changes in population dynamics of long-lived slow breeding mammals are rare, yet occurs. In 2019 the Eastern North Pacific Gray whale (*Eschrichtius robustus*) experienced an 'unusual mortality event' (UME), with 212 whales (as of September 30, 2019) found dead along the west coast of Mexico, the United States and Canada. To determine if nutritional stress could be underlying the 2019 unusual mortality event, we used unmanned aerial vehicles (UAV) and photogrammetry methods to compare the body condition of Gray whales in Laguna San Ignacio, a Gray whale breeding and calving area in Baja California Sur, Mexico, across three years of varying rates of calf production (calving rates): 2017 (normal calving rates), 2018 (medium calving rates) and 2019 (low calving rates).

Methods

Aerial photographs of Gray whales were collected with a DJI Inspire 1 Pro UAV Drone equipped with a Zenmuse X5 video camera and a 25mm lens, during 95 days in San Ignacio Lagoon, Mexico, in 2017 (March 5 – March 9), 2018 (January 17 – April 6) and 2019 (January 20 – March 23). The UAV was flown above the whales at altitudes ranging from 20 to 50 m (mean= 30 m) and recorded videos of the whales as they surfaced to breathe. During post-processing, a still frame photograph of each whale was extracted from the videos. An ideal photograph represented a whale lying flat at the surface with its dorsal side visible with its body non-arching and the body contour (both length and width) clearly visible (Fig. 1A). If the whale rolled over during sampling, we also extracted photographs of the lateral side (Fig. 2B). The body length and widths (at 5% increments along the entire body axis, Fig. 1A) of the whales were measured from the dorsal photographs using the custom-programmed Graphical User Interface. Similarly, from the lateral photographs we measured the body height (dorso-ventral distance) at the same measurement sites (Fig. 1B).

All measurements were scaled (converted from pixels to meters) using the known altitude of the UAV (measured using a LightWare SF11/C laser range finder), the camera sensor size, focal length and image resolution. Each whale was classified into a specific reproductive class: calf, juvenile, adult and lactating females.

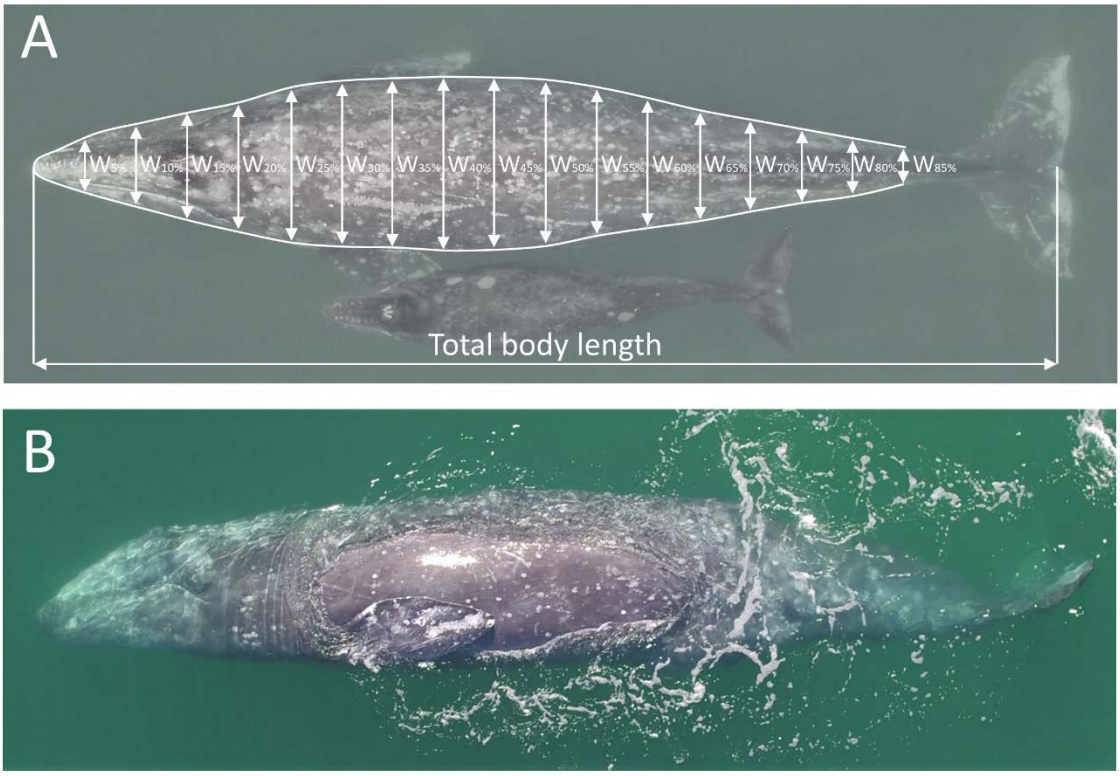

Fig. 1. Gray whale aerial photogrammetry measurement sites. (A) Example aerial photographs of the dorsal surface of a Gray whale, used to measure body length and width (W) at 5% increments along the body axis from 5% to 85% body length from the rostrum (white arrows). (B) Lateral side of another Gray whale, used to extract body height (dorso-ventral distance) along the same measurement sites.

Preliminary results

A total of 1,246 measurements were obtained, comprising 266 lactating females, 322 calves, 173 juveniles, and 485 adults. Of these, 75 were recorded in 2017, 531 in 2018 and 640 in 2019.

To calculate the whales' body condition, their volume was first estimated from the body length, width and height data. To account for the true body shape of the whales, the height-width (HW) ratio of the whales was first calculated, using the data from whales for which both dorsal width and lateral height measurements had been obtained (Fig. 2).

The cross-sectional body shape of the whales was slightly flattened in the lateral plane at the head region (0-20% body length (BL) from rostrum), almost circular in the mid region (20-50% BL from rostrum), and significantly flattened in the lateral plane across the posterior half of the body (50-85% BL from rostrum) (Fig. 2). This is the first study to quantitatively describe the cross-sectional body shape of Gray whales.

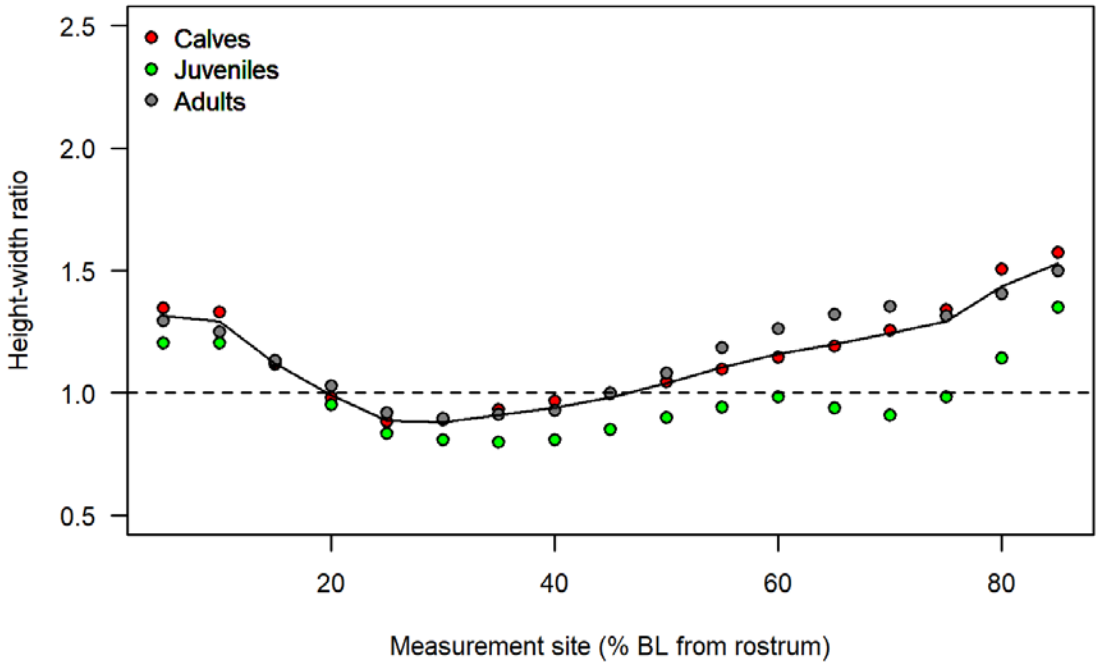

Fig. 2. Height-width ratios of Gray whales. Body height-width ratio of Gray whale calves (N= 21), juveniles (N= 4) and adults (N= 10) across the body from 5 to 85% BL from the rostrum (see Fig. 1 for location of measurement sites). The solid black line represents the average HW ratio of all reproductive classes. The dashed black line indicates a ratio of 1:1, equivalent to a circular cross-sectional body shape.

The body condition of individual whales was then calculated from the relationship between body volume and body length (Fig. 3), where any whale (black point) above the regression line (red line in Fig. 3) was considered to be in a relatively good condition (above the average of the population) and any whale (black point) below the regression line was considered to be in a relatively poor condition (below the average of the population).

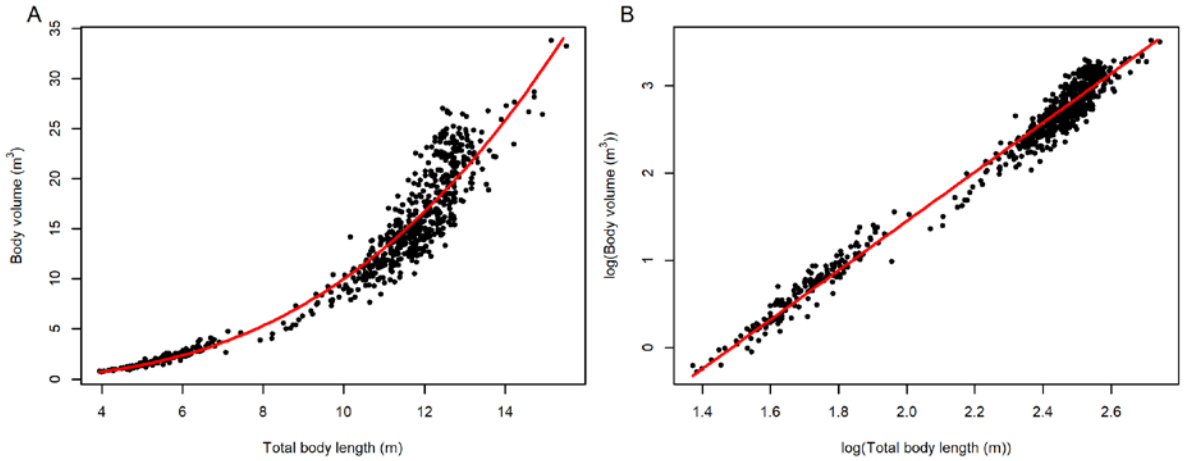

Fig. 3. Gray whale body volume versus body length relationship. (A) Gray whale body volume as a function of body length. (B) The log-log relationship between body volume and body length for the same data set. The red lines represent the average body condition of the population, with any data point above the line indicating a better body condition and any data point below the line indicating a poorer body condition.

The body condition of Gray whales in Laguna San Ignacio varied between reproductive classes (calves, juveniles, adults and lactating females) and years (Fig. 4). Overall, lactating females had the highest body condition, followed by calves, adults and finally juveniles (Fig. 4). The body condition of calves was higher in 2017 compared to the other year, however this was most likely because of the limited sampling period in 2017, which was restricted to March, when the calves will be of a larger size (i.e. body length) compared to January and February. Although there was large uncertainty in the body condition of juvenile and adult whales in 2017, due to small sample size, we found a significant difference in the body condition between juveniles and adults between 2018 and 2019, with whales in 2019 being in relatively poorer condition (Fig. 4). There was no difference in the body condition of lactating females between years (Fig. 4).

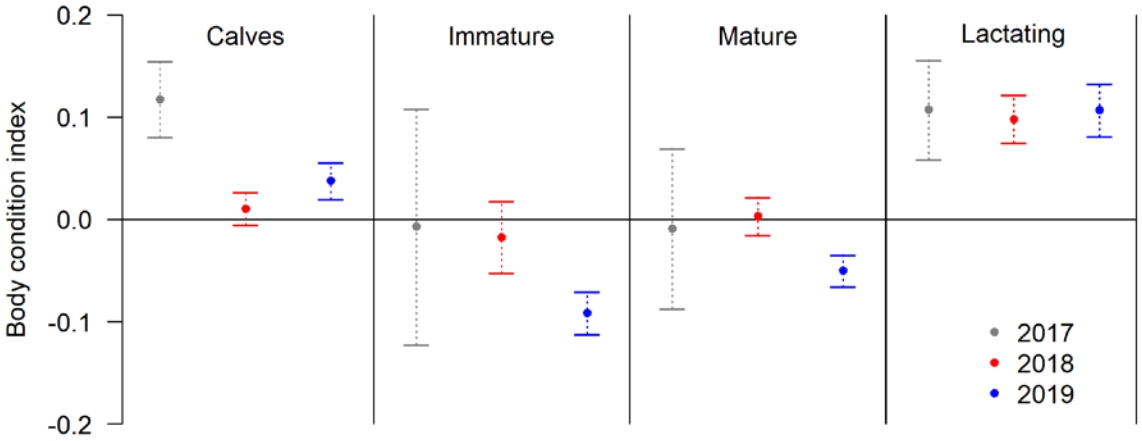

Fig. 4. Gray whale body condition in Laguna San Ignacio, between 2017 and 2019, divided into reproductive classes. The points indicate the mean body condition of different reproductive classes (calves, juveniles, adults and lactating females) in 2017 (grey points), 2018 (red points) and 2019 (blue points). The error bars represent 95 % confidence intervals.

Our preliminary findings suggest that Gray whales in Laguna San Ignacio were in poorer body condition in 2019, which coincides with the 'unusual mortality event' that occurred that year. The difference in body condition however, was only visible for juvenile and adult (non-lactating) whales, but not in lactating females or calves. This makes biological sense, since females that give birth and nurse their calves must already be in sufficiently good condition to complete gestation and the long migration to Laguna San Ignacio. Had the females been in poorer condition they might have lost their foetus or calf early on during the lactation phase. Similarly, since the lactating females were in good condition across years, there was no noticeable difference in the body condition of calves between 2018 and 2019.

Next steps

Further research is needed to account for temporal trends in the data. Calves are expected to grow through the breeding season in Mexico, during which time they might also change their general body shape (relative body width to length), which could be masking yearly variations in body condition. Similarly, lactating females will lose considerable body fat/condition through the breeding season as nurse and their calves grow in size. To account for this, we will investigate the relationship between maternal body condition and calf length as they grow, and also test if this relationship differs between years. Finally we will look at within-season variation in the body condition of juvenile and adult whales, to avoid potential sampling bias between years.

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